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(54) PRODUCTION OF STAINLESS STEEL SHEET

(57)Abstract:

PURPOSE: To produce a ferromagnetic stainless steel sheet showing corrosion resistance and workability suitable for a floppy disk center core or the like and furthermore having high surface hardness by specifying the chemical compsn. of a steel stock and the producing conditions of the steel sheet.

CONSTITUTION: A ferritic stainless steel having a compsn. contg., by weight, 0.01 to 0.10% C, 0.01 to 0.10% N, 0.1 to 2.0% Mn and 13.0 to 20.0% Cr, contg., at need, $\leq 0.1\%$ of one or more kinds among Ti, Nb, Ta and rare earth metals, and the balance Fe with impurities, and in which the contents of the following elements as the impurities are respectively regulated to $\leq 0.03\%$ P, $\leq 0.01\%$ S, $\leq 0.40\%$ Si, $\leq 0.01\%$ Al and $\leq 0.2\%$ Ni is used as a stock. At the time of subjecting this stock to cold rolling to produce a cold rolled steel sheet, the final cold rolling is executed at 10 to 90% draft by using a dull roll to regulate the surface roughness of the rolled stock to $\geq 0.1\mu\text{m}$ by Ra. After that, it is subjected to finish final annealing in a recovering region, suitably subjected to temper annealing in such a manner that it is heated to 750 to 900° C, is held for 10 to 60sec and is thereafter cooled to 400° C at 100 to 1000° C/sec.

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CLAIMS

[Claim(s)]

[Claim 1] It is C:0.01 - 0.10% at a weight rate. N:0.01 - 0.10% While containing Mn:0.1 - 2.0 % and Cr:13.0-20.0%, the remainder consists of Fe and an impurity. The content of P, S, Si, aluminum, and nickel which are an impurity, respectively And P:0.03% or less, S:0.01% or less, Si: Less than [0.40%], less than [aluminum:0.01%], Are made from the ferritic stainless steel of the chemical composition regulated below at nickel:0.2 %. The last cold rolling is carried out at workability:10-90% in cold-rolling this and manufacturing a cold rolled sheet steel using DARURO-RU, and it is Ra about the surface roughness of a rolled stock. After adjusting to 0.1 micrometers or more, The manufacture method of the high stainless steel plate of the surface hardness excellent in press-working-of-sheet-metal nature characterized by performing the last annealing of finishing in a recovery field.

[Claim 2] It is C:0.01 - 0.10% at a weight rate. N:0.01 - 0.10% While containing Mn:0.1 - 2.0 % and Cr:13.0-20.0%, the remainder consists of Fe and an impurity. The content of P, S, Si, aluminum, and nickel which are an impurity, respectively And P:0.03% or less, S:0.01% or less, Si: Less than [0.40%], less than [aluminum:0.01%], Are made from the ferritic stainless steel of the chemical composition regulated below at nickel:0.2 %. The last cold rolling is carried out at workability:10-90% in cold-rolling this and manufacturing a cold rolled sheet steel using DARURO-RU, and it is Ra about the surface roughness of a rolled stock. After adjusting to 0.1 micrometers or more, It considers as the last annealing of finishing and is characterized by performing temper annealing of the conditions which it becomes cooling rate:100-1000 degrees C /, and sec until it results in 400 degrees C after heating maintenance for heating temperature:750-900 degree C, and heating holding-time:10 to 60 seconds. The manufacture method of the high stainless steel plate of the surface hardness excellent in press-working-of-sheet-metal nature.

[Claim 3] As a ferritic-stainless-steel material, the total quantity further one sort in V, Ti, Nb, Ta, and REM, or two sorts or more The manufacture method of the high stainless steel plate of the surface hardness excellent in a claim 1 or press-working-of-sheet-metal nature given in 2 which uses what is contained in the range which does not exceed 0.1%.

[Claim 4] The manufacture method of the high stainless steel plate of the surface hardness excellent in press-working-of-sheet-metal nature given in the claim 1 or any of 3 they are. [which considers annealing before the last cold rolling as recrystallization annealing, and is characterized by carrying out the last cold rolling after this adjusts a grain size number to 50 micrometers or less]

[Claim 5] The manufacture method of the high stainless steel plate of the surface hardness excellent in press-working-of-sheet-metal nature given in the claim 1 or any of 4 they are. [which is characterized by performing the last annealing of finishing in a reducing atmosphere by which the dew-point was controlled by -30 degrees C or more]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention is equipped with high surface hardness, the outstanding press-working-of-sheet-metal nature, and corrosion resistance, for example, relates to the manufacture method of a ferromagnetic stainless steel plate suitable as an object for the center-cores of the floppy disk which is a magnetic-recording medium etc.

[0002]

[Description of the Prior Art] Although the thing of the form equipped with the center-core is increasing rapidly in the floppy disk used as a magnetic-recording medium in recent years, the following properties are needed for the material for these floppy disk center-cores.

(A) (B) which is excellent in corrosion resistance (C) which has ferromagnetism Surface hardness is high (230 or more Hv(s)). (D) a which is excellent in press-working-of-sheet-metal nature b with a high elongation value c with sufficient (an Erichsen value is high) punch stretchability d with sufficient (LDR and an r value are high) deep drawability e which a stretcher strain does not produce (there is no percentage yield elongation) A plastic anisotropy is small (delta r is small).

[0003] Then, generally to this use, the annealing board (recrystallization annealing board) of ferritic stainless steels (for example, SUS430 stainless steel etc.) has been used. The annealing board of a ferritic stainless steel is because sufficient value to perform press working of sheet metal to a floppy disk center-core was shown although have the high r value, and it excels in deep drawability, and was extended and the n value (work hardening factor), the Erichsen value, etc. were inferior to the austenitic stainless steel, while being a ferromagnetic material.

[0004] However, the following problems were pointed out when this ferritic-stainless-steel cold-rolled board was used as floppy disk center-core material. Namely, although it does not deteriorate so remarkably that a stretcher strain will not be produced, it will be extended in that case and an n value and an Erichsen value will also spoil press working of sheet metal, if a ferritic-stainless-steel cold-rolled board is processed after it performs light temper rolling of about 1% of workability although a stretcher strain will be produced, if press working of sheet metal is presented with an annealed material, the surface hardness in the state is as dissatisfied as about 150 Hv. Therefore, in order to realize Hv 230 demanded as floppy disk center-core material, the temper rolling after the last annealing needed to raise workability to at least 15% or more. However, it will be extended if the workability of temper rolling is raised even to the above-mentioned range, and an n value and an Erichsen value deteriorate remarkably, and how could not carry out that press-working-of-sheet-metal nature became bad easily.

[0005] For this reason, by this method, although the method of processing "the material which made elongation high at the sacrifice of surface hardness" into the center-core of a floppy disk, performing chrome plating after that, and obtaining high surface hardness was also considered, since there was a fault that a manufacturing cost is attached highly, it was not able to be said that it was practical.

[0006] Then, by JP,64-19570,A and JP,1-259144,A, having carried out proper quantity addition of Si and the nickel at composition of SUS430 system is advocated in the chemical composition of material that the above problems should be coped with. This tends to improve the toughness lost by addition of Si by addition of nickel while raising the degree of hardness of a material by adding Si. However, by this method, since cold rolling of about 15% of workability was too needed after the last annealing in order an improvement of about [that cost quantity and a bird clapper cannot escape] and a degree of hardness is not enough, either and to secure a required degree of hardness compared with the material of SUS430 usual system by addition of nickel, this also became loses ductility required for press-forming nature.

[0007] On the other hand, the method of obtaining the complex tissue of the ferrite phase which was rich in ductility at SUS43 steel-plate material, and a martensitic phase with a high degree of hardness is advocated by JP,63-14387,A and JP,63-169330,A, or the No. 169335 official report by performing the last annealing after cold rolling at an elevated temperature comparatively. However, there was a problem that the quality which management of annealing conditions was very difficult, therefore was stabilized was hard to be obtained since the temperature field where a ferrite phase and an austenite phase are intermingled by SUS430 system is narrow, although subsequent cold-rolled rolling (temper rolling) is not only unnecessary for this method, but a sufficient degree of hardness and sufficient ductility are acquired. But although condition management became easy since the temperature field where a ferrite phase and an austenite phase are intermingled became large when nickel was added as a steel-materials component in this case, it has not been disregarded that only the part which added nickel too serves as cost quantity compared with SUS430 system.

[0008] On the contrary, if JP,4-371518,A is seen, the material of SUS430 system is used as it is, and the method of annealing at low temperature is advocated after cold-rolled rolling. According to this method, since it is not made to recrystallize after cold-rolled rolling, there are few falls of a degree of hardness and it needs, and ductility is recovered, so that it is enough for press-forming nature. However, although it was a low annealing temperature therefore, material carried out sensitization and the problem that corrosion resistance deteriorated was in this method by ****. Then, in order to acquire sufficient corrosion resistance, passivation processing in which it electrolyzes in nitric-acid solution is needed, and it could not escape becoming cost quantity.

[0009] Since it was such, this invention's having considered as the purpose was establishing a means the ferromagnetic stainless steel plate which showed the outstanding corrosion resistance and the outstanding processability suitable as an object for floppy disk center-cores etc., and also had high surface hardness being

offered stably and cheaply.

[0010]

[Means for Solving the Problem] "The result which inquired wholeheartedly that this invention person etc. should attain the above-mentioned purpose, are made from the steel which fully controlled the content of the specific trace element (impurity element) which tends to be inevitably contained in the ferritic stainless steel which has ferromagnetism, the cold-rolled board which carried out the cold rolling and annealing at the time of processing it into sheet metal material further on condition that specification, and finished them. Always having high surface hardness and the outstanding processability it comes to have the corrosion resistance which was excellent even if it did not perform passivation processing of nitric-acid electrolysis etc. after that. The new knowledge that it might become the material which was very excellent as floppy disk center-core material" was able to be acquired.

[0011] It is completed based on the above-mentioned knowledge matter, and this invention is "C:0.01-0.10% (henceforth). % showing weight rate is N:0.01 - 0.10% made into weight %, Mn:0.1 - 2.0 % [whether Cr:13.0-20.0% is contained and] One or more sorts of or further V, and Ti, Nb, Ta and REM (rare earth elements and Y): With the total quantity While containing 0.1% or less The remainder consists of Fe and an impurity. The content of P, S, Si, aluminum, and nickel which are an impurity, respectively And P:0.03% or less, S:0.01% or less Less than [Si:0.40%], less than [aluminum:0.01%], Are made from the ferritic stainless steel of the chemical composition regulated below at nickel:0.2 %. In cold-rolling this and manufacturing a cold rolled sheet steel (annealing and rolling usually being repeated by turns) After adjusting a grain size number to 50 micrometers or less preferably by considering annealing before the last cold-rolled rolling as recrystallization annealing It carries out at workability:10-90% using DARURO-RU (roll which split-face--ization-finished the front face), and the last cold rolling is Ra about the surface roughness of a rolled stock. After adjusting to 0.1 micrometers or more, the last annealing of finishing in recovery field -- cooling rate:100-1000 degree C [until it results in 400 degrees C after heating maintenance suitably for heating temperature:750-900 degree C, and heating holding-time:10 to 60 seconds] /sec -- by performing temper annealing of conditions It is carrying out these annealing suitably by and also the reducing atmosphere by which the dew-point's was controlled by -30 degrees C or more. It has the big feature at the point of having enabled it to manufacture stably and cheaply the high stainless steel plate of the surface hardness excellent in press-working-of-sheet-metal nature.

[0012] In addition, even if "temper annealing" said by this invention avoids softening and sensitization, aims at recovery of toughness and does not perform passivation processing of subsequent cold rolling (temper rolling), electrolysis among nitric-acid solution, etc. by this by adjusting atmosphere, heating time, the holding time, and a cooling rate, it means heat treatment for realizing sufficient intensity and sufficient corrosion resistance.

[0013]

[Function] Next, the reason which limited the manufacture conditions of the chemical composition of material steel or a steel plate like the above in this invention is explained more to a detail.

A) Although it is a component required for the chemical composition [C] C of material steel to aim at fixing of the dislocation which exists in a steel plate, and secure the intensity of a steel plate, and surface hardness, in order for the content to fix dislocation at less than 0.01% and not to go out, sufficient intensity is not obtained, but work-hardening ability also falls. On the other hand, since the carbide of Cr will deposit, and a steel plate will stiffen and the depleted zone of Cr will arise around the sludge if C is made to contain exceeding 0.1%, corrosion resistance also deteriorates. Therefore, C content determined it as 0.01 - 0.10%.

[0014] [N] Although it is a component required for N to also aim at fixing of the dislocation which exists in a steel plate, and secure the intensity of a steel plate, and surface hardness, in order for the content to fix dislocation at less than 0.01% and not to go out, sufficient intensity is not obtained, but work-hardening ability also falls. On the other hand, since the nitride of Cr will deposit, and a steel plate will stiffen and the depleted zone of Cr will arise too around the sludge if N is made to contain exceeding 0.1%, corrosion resistance also deteriorates. Therefore, N content determined it as 0.01 - 0.10%.

[0015] [Mn] There is work which raises the effect that C and N fix dislocation to Mn, and the desirable content for acquiring the maximum effect is decided by the content of C or N. And Mn content as a result of an experiment The effect that C and N fix transposition as it is less than 0.1% cannot fully be heightened, but it is conversely. Even if it made it contain exceeding 2.0%, that it is saturated and is meaningless made the aforementioned effect clear. Therefore, Mn content determined it as 0.1 - 2.0 %.

[0016] [Cr] Cr is also a typical ferrite formation element while being a component required in order to secure desired corrosion resistance to a steel plate. And although it is enough if 12% or more of Cr content is secured for attaining the corrosion resistance required of floppy disk center-core material etc., in order to obtain the stable ferrite, it is necessary to adjust Cr content to 13.0% or more. That is, the temperature field where an austenite phase appears that Cr content is less than 13.0% is very large, therefore a steel plate serves as martensitic structure by the cooling process after the last annealing end depending on the case, and elongation falls remarkably. On the other hand, even if it makes Cr contain exceeding 20.0%, it is not connected with actual **** only by raw material cost becoming expensive. Therefore, Cr content determined it as 13.0 - 20.0%.

[0017] [P] It not only injures hot-working nature, but P degrades corrosion resistance. Moreover, also itself P not only tends to carry out a segregation, but promotes the segregation of other elements. Furthermore, toughness is degraded, although a deposit of carbide is promoted and intensity is raised. That is, since such an obstacle made it remarkable when the content of P exceeded 0.03%, the upper limit of the content of P was determined as 0.03%.

[0018] [S] S is an element which forms the eutectic film of the low melting point in a grain boundary, and injures hot-working nature, and since it is easy to form sulfuration system inclusion, although cutting ability is raised, degrades corrosion resistance remarkably. And if the content of S exceeded 0.01%, in order that above-mentioned un-arranging might make it remarkable, the upper limit of S content was determined as 0.01% or less.

[0019] [Si] While Si is an effective deoxidizer, when it also has the operation which raises tensile strength and proof stress and is made to contain 1% or more, although corrosion resistance improves, toughness is spoiled and a good moldability is no longer obtained. of course, although the effective and suitable improvement effect in the strength is securable for deoxidation even if it is the content which is less than 1%, when corrosion resistance deteriorates remarkably and anneals in a distorted recovery field after cold working like especially this invention, no matter it may anneal on what conditions, it stops avoiding sensitization in "0.40%<Si<1.0%" of range. Therefore, upper limit of Si content It was determined as 0.4%.

[0020] [aluminum] Although it is added as a deoxidizer and a grain-refining element and aluminum usually has an

effect in reduction of oxidization system inclusion, and improvement in hot-working nature, on the other hand, it is easy to deposit a nitride, therefore the evil in which toughness is spoiled is also brought about. And since toughness degradation would turn notably and would spoil press-forming nature when aluminum content exceeded 0.01%, the upper limit of aluminum content was determined as 0.01%.

[0021] [nickel] nickel is an element which is easy to invade into steel through the scrap of an auxiliary raw material etc., and since it raises the activity coefficient of C while it carries out the work which raises toughness, it acts so that lack of Cr may be promoted. And since required corrosion resistance was no longer acquired when the last annealing was performed in the distorted recovery field so that the operation might become remarkable and it might mention later, if the content of nickel exceeded 0.2 %, the upper limit of nickel content was determined as 0.2 %.

[0022] [V, Ti, Nb, Ta, REM (rare earth elements and Y)] Since V, Ti, Nb, or Ta has the affinity stronger than Cr to C, there is an effect which suppresses a deposit of Cr carbide, the sensitization in the case of the last annealing later mentioned by it is barred, and its corrosion resistance improves. moreover, these elements deposit detailed and stable carbide in a grain boundary, and in case the effect which makes crystal grain detailed makes crystal grain detailed in annealing before the last cold rolling mentioned later for a certain reason, they act effectively. On the other hand, REM (rare earth elements and Y) raises corrosion resistance by deposit of stable carbide while improving the cleanliness and hot-working nature of steel. therefore, in order to acquire the above-mentioned effect, although two or more sorts respond required and are made to contain, if those sum total contents exceed 0.1 %, a dissolution component will condense unevenly on a front face, roll imprint nature will get worse, and these one sort or the material which has good surface roughness is no longer obtained. For this reason, the upper limit of the sum total content of V, Ti, Nb, Ta, or rapid eye movement was determined as 0.1 %.

[0023] B) By the condition this invention method of annealing carried out before the last cold rolling, since the last annealing in the manufacturing process of a cold rolled sheet steel is not recrystallization annealing but "annealing in a recovery field", the surface hardness of product steel plates (floppy disk center-core material etc.) is influenced by the diameter of crystal grain of the material obtained by annealing before the last cold rolling. Therefore, in order to make surface hardness of a product steel plate high, it is necessary to control from the stage of annealing before the last cold rolling, so that the diameter of crystal grain becomes as small as possible. Moreover, when the diameter of crystal grain at this time was large and press working of sheet metal is performed, surface deterioration will be produced, and the appearance of a product will be spoiled. However, if the diameter of crystal grain of material is adjusted to 50 micrometers or less at the time of annealing (it is generally distorted and annealing is performed) carried out before the last cold rolling, a possibility of sufficient surface hardness for a product steel plate being secured, and producing surface deterioration at the time of press working of sheet metal will also disappear, and much more good press-forming nature will be obtained. Therefore, as for annealing before the last cold rolling, it is desirable to consider as recrystallization annealing of the conditions from which the diameter of crystal grain of material is set to 50 micrometers or less. In addition, it cannot be overemphasized that adjustment of the diameter of crystal grain is performed by adjusting an annealing temperature, annealing conditions, etc.

[0024] C) It is necessary to carry out the last cold rolling at 10 - 90% of workability by the workability this invention of the last cold rolling. Here, the lower limit of the workability of the last cold rolling was made into 10% for adjusting the dislocation density in material moderately. That is, since the material stainless steel concerning this invention by which the chemical composition was regulated is a very stable ferrite phase (bcc structure), C which is an invaded type dissolution element, and N carry out the work which fixes dislocation. And many dislocation" should fix with those elements from "by annealing in the recovery field which is the following process to obtain on-the-strength" higher than ", and before progressing to the following process, it is necessary to increase the dislocation in material moderately. In order to fully acquire this effect, you have to carry out the last cold rolling by 10% or more of workability.

[0025] Moreover, cold working before annealing also has the effect of shifting sensitization temperature to a low temperature side. That is, if sufficient cold working is added and processing distortion is increased, it becomes impossible for sensitization to happen by the elevated-temperature side of the usual sensitization temperature field, and corrosion resistance degradation can be escaped. And if it carries out from this viewpoint, it is necessary to make workability of the last cold rolling 40% or more. However, since processing strong against a material-list side will be added even if friction between a roll and material becomes large and is low workability if it rolls out using DARURO-RU, workability smaller than 40% can also fully secure the aforementioned effect. And processing distortion which joins a material-list side becomes large, and becomes more remarkable [this effect], so that surface roughness of DARURO-RU is made high. When the aforementioned effect began to show up though workability was 10% when the surface roughness of the steel plate obtained by rolling became more than Ra 0.1micrometer, and surface roughness consisted of test results, such as this invention person, more than Ra 0.3micrometer, it was checked that sufficient effect is securable.

[0026] On the other hand, if the workability of the last cold rolling is too high, since rolling texture will become strong and a plastic anisotropy will become large, press-forming nature gets worse. If the aforementioned workability exceeds 70%, it will come to appear, if especially this workability exceeds 90%, a problem will turn notably, for example, these signs come to produce fault in press forming, such as a floppy disk center-core. Therefore, in the last cold rolling, it was determined that it supposed that DARURO-RU from which the surface roughness of the rolled stock obtained becomes more than Ra 0.1micrometer (preferably Ra 0.3 micrometer more than) is used, and rolled out at workability:10-90% (preferably 40 - 70%).

[0027] D) It is especially to have considered the last annealing carried out after the condition last cold rolling of the last annealing as "annealing in a recovery field (distorted recovery field)" instead of "recrystallization annealing". b which obtains required intensity and surface hardness c which does not produce a stretcher strain it is for securing three effects of making a plastic anisotropy (deltar) small to a product steel plate. That is, if it is made to recrystallize, not only the intensity of a product steel plate and surface hardness fall, but the quality of the material will become easy to produce a stretcher strain harder [with a ferritic stainless steel]. Moreover, a recrystallization texture also has the fault that a plastic anisotropy is larger than rolling texture. However, as much as possible, it is small, and the scale which can expect "strengthening by C which is an invaded type dissolution element, and N fixing the movable dislocation obtained by the last cold rolling" when temper annealing of suitable conditions is performed, and a plastic anisotropy also becomes, without producing a stretcher strain.

[0028] However, although sensitization will stop being able to happen easily due to an elevated-temperature side if cold working sufficient before annealing is performed as mentioned above, in a low temperature side, sensitization

becomes easy to happen conversely. Furthermore, it is since productivity also falls compared with annealing of an elevated-temperature short time when there is a danger of stiffening in annealing prolonged at low temperature. cooling rate: 100-1000 degree C [in order to secure an efficient expected effect, until it results in 400 degrees C after heating maintenance for heating temperature: 750-900 degree C (preferably 800-850 degrees C), and heating holding-time: 10 to 60 seconds (preferably 15 - 20 seconds)]/sec -- it is desirable to perform temper annealing which is the elevated-temperature short time of conditions

[0029] Here, if heating temperature exceeds 900 degrees C, preservation of the quality which was easy to recrystallize and was stabilized will become difficult, and, on the other hand, corrosion resistance will deteriorate like known that it is low temperature from 750 degrees C. And if it holds [annealing by heating of the above-mentioned temperature region, and] to a soaking zone for 60 seconds, it is enough, and when time maintenance is carried out, there is also a possibility of the longer danger of recrystallizing than it coming out upwards, and the amount of deposits of the carbide of Cr or a nitride increasing, and stiffening. On the other hand, sufficient ductile recovery is not performed with the heating holding time being less than 10 seconds, or there is a danger of causing corrosion resistance degradation. This is because the so-called "sensitization phenomenon" tends to occur in heating of the above-mentioned temperature region: [say / that the depleted zone of Cr arises temporarily around the sludge immediately after carbide and the nitride of Cr tend to deposit and deposit, and corrosion resistance is spoiled remarkably] Of course, if sufficient time corresponding to the diffusion rate of Cr passes, although supply of Cr from the circumference will be performed to the depleted zone of Cr and corrosion resistance degradation will be escaped, it is difficult in the above-mentioned temperature region to expect supply of Cr from the circumference to within a time [for less than 10 seconds].

[0030] Moreover, when the cooling rate after heating maintenance is slow, there is a possibility that the carbide or the nitride of Cr may deposit in the middle of cooling. When it cools from 800 degrees C or more especially, the sensitization of the deposit of the carbide of Cr is very easy to be carried out. But it is a cooling rate at the time of aiming at it, although corrosion resistance degradation was escaped, when cooling at the speed carried out slowly so that supply of Cr from the circumference was fully performed to the depleted zone of Cr. Since it must control it below 0.1 degrees C / sec and productivity will fall remarkably, this method is not desirable on real operation. In addition, what carbide and the nitride of Cr tend to deposit in is to 400 degrees C, and even if it cools slowly in a low temperature field from this, there is no inconvenience. Thus, when a cooling rate after carrying out heating maintenance, until it reaches a 750-900-degree C temperature region at 400 degrees C is slower than 100 degrees C/sec, the danger that a sensitization phenomenon will arise increases. However, a real operation top is impossible for realizing the cooling rate exceeding 1000 degrees C/sec, and if it carries out from these points, it can be said that it is practical to cool with the cooling rate before and behind 600 degrees C / sec.

[0031] In addition, it is desirable to perform annealing processing mentioned above in "a reducing atmosphere (for example, AX gas atmosphere) by which the dew-point was controlled by -30 degrees C or more", a stable oxide film is formed in a material-side by this, and corrosion resistance improves further.

[0032] As mentioned above, since the stainless steel plate manufactured according to this invention method is the organization of only a ferrite phase, it has ferromagnetism, and it demonstrates the corrosion resistance which was excellent since 13.0 - 20.0% of Cr was contained as the component. Furthermore, it is extended although surface hardness is high, and an n value, an r value, and an Erichsen value are high, and the press-working-of-sheet-metal nature which was excellent since a stretcher strain moreover did not arise is shown. Therefore, this stainless steel plate has fully satisfied many properties required of the charge of floppy disk center-core material, and when it is used as an object for floppy disk center-cores, it can attain the further improvement in a performance.

[0033] Subsequently, it is a book by the example.

[Example] first, after a converter performs the quality governing of a molten metal, pass vacuum degassing and continuous casting -- every of the chemical-composition composition shown in Table 1 and 2 -- the Fe-Cr system alloy (ferritic stainless steel) cast piece was obtained

[0034]

[Table 1]

表 1

① 鋼 種	③ 化 学 成 分 (重量%)										
	C	N	Mn	Cr	P	S	Si	Al	Ni	④ その他	
② 本 発 明 対 象 鋼	A	0.034	0.0187	0.81	18.03	0.015	0.003	0.25	<0.001	0.15	—
	B	0.045	0.0125	0.89	1.712	0.013	0.005	0.23	0.002	0.12	—
	C	0.023	0.0113	0.78	15.95	0.012	0.003	0.20	<0.001	0.18	Nb: <0.001
	D	0.060	0.0189	0.93	18.48	0.019	0.004	0.24	0.001	0.13	V: <0.001
	E	0.051	0.0145	0.75	18.25	0.014	0.004	0.29	0.001	0.14	—
	F	0.039	0.0162	0.88	18.56	0.016	0.003	0.21	0.002	0.19	V: 0.011
	G	0.025	0.0136	0.83	18.78	0.018	0.005	0.27	0.001	0.11	Nb: 0.012
	H	0.053	0.0178	0.79	18.69	0.011	0.004	0.22	0.002	0.17	Ti: 0.001
	I	0.063	0.0116	0.90	18.83	0.010	0.004	0.28	<0.001	0.10	Ta: 0.001
	J	0.048	0.0127	0.87	17.02	0.017	0.005	0.28	0.002	0.18	Y: 0.006
	K	0.033	0.0135	0.75	18.23	0.015	0.003	0.25	0.001	0.15	V: 0.010, Co: 0.005
	L	0.045	0.0140	0.81	18.58	0.013	0.005	0.23	0.001	0.11	Ti: 0.001, Y: 0.008
M	0.050	0.0128	0.85	18.77	0.012	0.003	0.20	<0.001	0.13	Nb: 0.010, Ta: 0.002	

⑥ (注) 残部成分はFe及び不純物である。

- ① steel type
- ② steel of this invention
- ③ chemical composition (wt%)
- ④ others
- ⑤ (annotation) the balance composed of Fe, and inevitable impurities

[0035]
[Table 2]
表 2

①鋼種		③化 学 成 分 (重量%)									
種		C	N	Mn	Cr	P	S	Si	Al	Ni	④そ の 他
②發明対象鋼	N	0.053	0.0176	0.82	16.69	0.010	0.004	0.25	0.002	0.14	Y: 0.096
	O	0.046	0.0125	0.83	17.12	0.019	0.004	0.27	0.002	0.17	Ti: 0.026
	P	0.025	0.0138	0.87	16.78	0.012	0.005	0.29	0.002	0.18	Ta: 0.055
⑤比較鋼	Q	*0.153	0.0132	0.86	16.25	0.012	0.005	0.23	<0.001	0.12	V: 0.053
	R	0.039	*0.0004	*0.07	16.56	0.014	0.003	0.21	<0.001	0.13	Nb: 0.064
	S	0.027	0.0145	0.80	*11.12	0.011	0.004	0.22	<0.001	0.15	Ti: 0.022
	T	0.056	0.0113	0.85	15.00	*0.075	0.005	0.20	0.001	0.11	Ta: 0.046
	U	0.063	0.0116	0.81	12.83	0.012	*0.037	0.26	0.001	0.10	Y: 0.023
	V	0.048	0.0127	0.88	13.02	0.018	0.004	*0.84	0.001	0.18	V: 0.048
	W	0.034	0.0197	0.84	16.03	0.015	0.005	0.28	* 0.153	0.16	Nb: 0.034
	X	0.045	0.0125	0.83	17.12	0.019	0.004	0.27	0.002	*1.17	Ti: 0.028

⑦ (注1) 残部成分はFe及び不純物である。

⑧ (注2) *印は、本発明で規定する条件から外れていることを示す。

- ⑤ comparative steel
- ⑥ (annotation 1) the balance composed of Fe, and inevitable impurities
- ⑦ (annotation 2) * mark means out of this invention

[0036] Next, after hot-rolling these cast pieces and performing surface care and cleaning of pickling etc., cold rolling and annealing are repeated and it is board thickness:0.3mm. It considered as the cold-rolled board and the last annealing was further given in the reducing atmosphere after the last cold rolling. Here, in the last cold-rolled rolling, DARURO-RU which carried out dull processing of the front face as a work roll was used. In addition, "the diameter of crystal grain at the time of annealing before the last cold rolling" in this case, "the workability of the last cold rolling", "surface roughness Ra", and "the conditions of the last annealing" were as being shown in Table 3 and 4.

[0037]
[Table 3]

[0038]
[Table 4]

表 3

① 試験番号	② 適用鋼種	③ 最終圧延前の焼鈍での結晶粒径(μm)	④ 最終圧延の加工度(%)	⑤ 圧延後の材料の表面粗さRa(μm)	⑥ 最終焼鈍の条件				⑦ 得られた鋼板の特性						⑫ 耐食性
					⑧ 露点(°C)	⑨ 温度(°C)	⑩ 時間(秒)	⑪ 冷却速度(°C/sec)	⑬ 表面硬さHv(1.0)	⑭ 伸び(%)	⑮ 引れ値	⑯ Δr	⑰ カップ耳高さ(mm)	⑱ 降伏点現象の有無	
1	A	52	75	0.76	-55	850	18	500	230	11.0	6.5	0.27	0.5	⑰ 無	○
2	B	15	20	0.68	-45	760	38	500	231	10.1	6.0	0.26	0.6	⑰ 無	○
3	C	10	15	0.35	-52	880	12	600	236	9.7	5.9	0.26	0.7	⑰ 無	○
4	D	60	80	0.28	-53	890	11	600	232	10.9	6.6	0.24	0.6	⑰ 無	○
5	E	55	78	0.13	-50	760	52	500	232	10.8	6.5	0.23	0.5	⑰ 無	○
6	F	10	62	0.61	-28	840	21	600	256	10.2	6.0	0.28	0.8	⑰ 無	◎
7	G	10	55	0.74	-27	830	20	550	260	10.0	6.0	0.20	0.5	⑰ 無	◎
8	H	15	67	0.59	-25	850	19	550	150	10.5	6.2	0.27	0.6	⑰ 無	◎
9	I	15	50	0.34	-25	870	17	500	258	10.1	6.0	0.23	0.7	⑰ 無	◎
10	J	10	57	0.43	-21	860	16	600	256	10.2	6.1	0.26	0.5	⑰ 無	◎
11	K	20	30	0.55	-20	850	20	500	251	10.5	6.2	0.21	0.5	⑰ 無	◎
12	L	30	40	0.66	-15	830	25	300	252	10.3	6.4	0.23	0.5	⑰ 無	◎
13	M	40	50	0.44	-25	880	30	700	253	10.4	6.3	0.22	0.5	⑰ 無	◎

⑧ 本 発 明 例

(P) 本 発 明 例

- ① examination No.
 ② applied steel
 ③ diameter of crystal grain of the material obtained by annealing before the last cold rolling
 ④ workability of last cold rolling
 ⑤ surface roughness Ra after rolling (μm)
 ⑥ condition of the last annealing
 ⑦ dew point (°C)
 ⑧ temperature (°C)
 ⑨ time (second)
 ⑩ cooling rate (°C/sec)
 ⑪ characteristic of produce steel plate
 ⑫ surface hardness Hv(1.0)
 ⑬ elongation (%)
 ⑭ Erichsen value
 ⑮ cup ear height (mm)
 ⑯ whether the stretcher strain occurred
 ⑰ corrosion resistance
 ⑱ example of this invention
 ⑲ none

① 試験番号	② 適用鋼種	③ 最終圧延前の焼却での結晶粒径 (μm)	④ 最終圧延の加工度 (%)	⑤ 圧延後の材料の表面粗さRa (μm)	⑥ 最終焼却の条件				⑦ 得られた鋼板の特性						
					⑧ 焼点 (°C)	⑨ 温度 (°C)	⑩ 時間 (秒)	⑪ 冷却速度 (°C/sec)	⑫ 表面硬さ Hv(L0)	⑬ 伸び (%)	⑭ IFF値	⑮ Δr	⑯ カップ耳高さ (mm)	⑰ 降伏点現線の有無	⑱ 耐食性
14	N	5	* 5	* 0.02	-47	750	44	500	175	11.8	8.2	0.27	0.6	無	×
15		5	65	0.44	-35	870	* 4	500	285	6.5	4.2	0.27	0.6	無	×
16	O	9	* 9.5	0.47	-15	870	16	500	278	6.4	4.0	0.63	1.0	無	◎
17	P	6	88	0.66	-45	870	58	400	152	31.5	9.8	0.44	0.9	有	○
18	*Q	6	67	0.46	-40	860	22	550	275	8.6	4.8	0.23	0.6	無	×
19	*R	5	70	0.53	-35	830	21	600	214	11.2	6.5	0.28	0.7	無	○
20	*S	8	65	0.62	-28	840	20	600	253	9.9	6.0	0.27	0.4	無	×
21	*T	9	57	0.43	-42	850	19	500	269	7.1	4.9	0.28	0.4	無	×
22	*U	8	68	0.36	-32	850	18	550	257	10.3	5.1	0.23	0.5	無	×
23	*V	7	55	0.28	-36	860	17	550	268	8.6	5.0	0.22	0.4	無	×
24	*W	8	63	0.49	-31	840	16	600	260	6.8	3.9	0.26	0.7	無	○
25	*X	9	58	0.37	-39	870	16	500	258	11.4	7.1	0.23	0.5	無	×

(注) *印は、本発明で規定する条件から外れていることを示す。

(20) Comparative example

(21) * = out of the conditions of this invention

① 試験番号	② 適用鋼種	③ 最終圧延前の焼鈍の結晶粒径 (μm)	④ 最終圧延の加工度 (%)	⑤ 圧延材料の表面粗さ (μ1)
14	N	5	5	0.0
15		5	65	0.4
16	O	9	95	0.4
17	P	6	88	0.6
18	Q	6	67	0.4
19	R	5	70	0.5
20	S	8	65	0.6
21	T	9	57	0.4
22	U	8	68	0.5
23	V	7	55	0.5
24	W	8	63	0.4
25	X	9	58	0.5

表 4

(注) *印

[0039] Here, surface roughness Ra shown in Table 3 and 4 is called center line average coarseness, and follows the definition and measuring method which were set to JIS etc. That is, it is measurement length L to the direction of a roughness curve to the center line. A portion is sampled, the Y-axis is set as the direction of the X-axis and longitudinal magnification for the center line of this sampling portion, and it is a roughness curve $y=f(x)$. It is a degree when expressed. The value expressed by (1) formula is expressed with a MAIKUROME-torr (micrometer).

[0040]

[Equation 1]

$$Ra = \frac{1}{L} \int_0^L |f(x)| dx \quad \dots\dots\dots (1)$$

[0041] and each stainless steel cold rolled sheet steel obtained as mentioned above -- attaching -- the -- "Surface hardness", "Press-working-of-sheet-metal nature" and -- "Corrosion resistance" It investigated and the result was collectively shown in aforementioned Table 3 and 4. Here, the Vickers hardness number whose load is 1kg estimated "surface hardness." Moreover, it investigated by measuring the Erichsen value for evaluating elongation and punch stretchability, "deltar" for evaluating a plastic anisotropy, and "cup ear height" about "press-working-of-sheet-metal nature." in addition, a value in case elongation is 5% about an r value -- asking -- cup ear height -- diameter of punch: -- blank 33mm -- it asked by performing a path:63mm cupping test Furthermore, although it investigated also about whether the stretcher strain occurred when press working of sheet metal was carried out, since this was judged with whether a yield phenomenon appears when a tension test was performed, it evaluated by "existence of a yield point phenomenon" about the stretcher strain. on the other hand -- "corrosion resistance" -- being related -- 5% sodium chloride solution -- a salt spray test -- carrying out -- evaluating -- Table 3 and 4 -- the evaluation result -- O-- very -- good An O-- good x-- it displayed by the poor three-stage

[0042] The following matter is clear from the result shown in Table 3 and 4. That is, the product steel plate concerning the examples 1-13 of this invention is excellent in press-forming nature, when surface hardness has satisfied "230 or more Hv(s)" for all, and its corrosion resistance is also good. Since especially the steel plate concerning the examples 6-13 of this invention is controlled by the size also with the desirable grain size number which is carrying out proper quantity content of the trace elements, such as V, and should be adjusted by annealing before a ultimate-pressure total and the dew-point in the last annealing is also controlled by desirable temperature, the more desirable result is obtained. Moreover, since the organization of the steel plate concerning the above-mentioned example of this invention is only a ferrite, it has ferromagnetism. thus, following un-arranging were pointed out to the steel plate concerning the example of comparison to having been [which satisfies all the properties demanded as a charge of-floppy disk center-core material which described previously each steel plate concerning the example of this invention]

[0043] The content of C the steel plate concerning the example 18 of comparison Since it is over 0.1%, the carbide of Cr deposits so much, it stiffens, and corrosion resistance has also deteriorated. Since the steel plate concerning the example 19 of comparison has few contents of N and Mn than the default value of this invention, sufficient surface hardness is not obtained. Since the steel plate concerning the example 20 of comparison has few contents of Cr than 13%, it is inferior to corrosion resistance. Ductility with the steel plate sufficient since the content of P is over 0.02% concerning the example 21 of comparison was not acquired, but corrosion resistance has also deteriorated. Since the content of S is over 0.01%, as for the steel plate concerning the example 22 of comparison, corrosion resistance has deteriorated. The content of Si the steel plate concerning the example 23 of comparison Since it was over 0.4%, ductility fell, and corrosion resistance has also deteriorated. The content of aluminum the steel plate concerning the example 24 of comparison Since it is over 0.1%, ductility is falling. The content of nickel the steel plate concerning the example 25 of comparison Since it is over 0.2%, corrosion resistance has deteriorated.

[0044] On the other hand, since the workability of a ultimate-pressure total is less than 10%, sufficient surface hardness is not obtained, but the steel plate concerning the example 14 of comparison is also surface roughness Ra further. Since it is less than 0.1 micrometers, sensitization happened and corrosion resistance has also deteriorated. On the contrary, for the steel plate concerning the example 16 of comparison, a plastic anisotropy is ***** alth ough the value with satisfactory surface hardness is acquired, since the workability of a ultimate-pressure total is over 90%. If press working of sheet metal of this steel plate is carried out to the floppy disk center-core required of a high forming system, poor forming will arise.

[0045] Since the steel plate concerning the example 17 of comparison set the temperature of the last annealing as 900 degrees C or more, it recrystallized, and required hardness was not obtained but it has also produced the yield point phenomenon. Moreover, since it is a recrystallization texture, a plastic anisotropy is large, and the same

obstacle as the example 16 of comparison occurs. Since, as for the steel plate concerning the example 15 of comparison, heating time is less than 10 seconds in the last annealing, sensitization has happened.

[0046]

[Summary of Effects] While high surface hardness is shown according to this invention even if it has ferromagnetism and does not give hard chromium plating etc. as explained above, a very useful effect is brought about on industry, such as becoming possible to offer stably and cheaply the floppy disk center-core material which is excellent also in press-working- f-sheet-metal nature and corrosion resistance.

[Translation done.]